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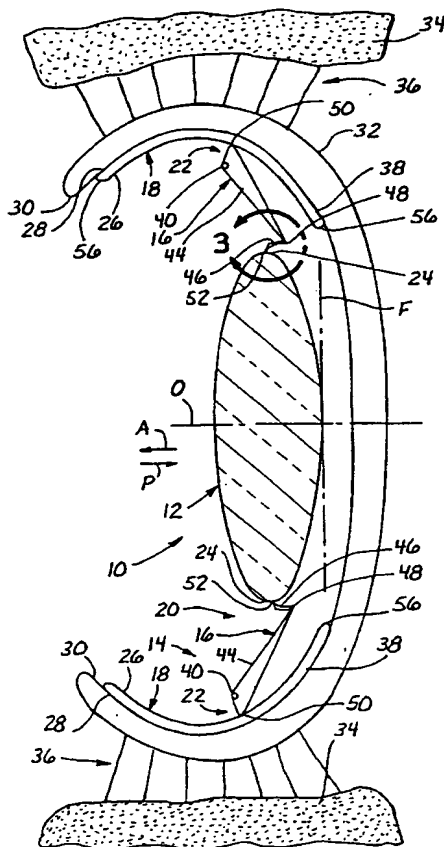
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(54) Title: ACCOMMODATING INTRAOCULAR LENS WITH SUSPENSION STRUCTURE



(57) Abstract: An intraocular lens includes an optic for focusing light and a movement assembly coupled to the optic. The movement assembly is adapted to cooperate with the eye to effect accommodating movement of the optic. The movement assembly includes a plurality of movement members and a suspension structure. The movement members are coupled to a periphery of the optic. The suspension structure is coupled to the movement members and is adapted to be in contact with a peripheral region of a capsular bag of an eye. The movement members are adapted to convert radial movement of the suspension structure caused by movement of the capsular bag to axial movement of the optic. The movement members are also adapted to amplify the radial movement of the suspension structure so that the optic moves axially a greater distance than the distance moved radially by the suspension structure.

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ACCOMMODATING INTRAOCULAR LENS WITH
SUSPENSION STRUCTURE

Background of the Invention

The present invention relates to intraocular lenses (IOLs). More particularly, the present invention relates to IOLs that provide accommodating movement in the eye.

5 The human visual system includes the eyes, the extraocular muscles which control eye position within the eye socket, the optic and other nerves that connect the eyes to the brain, and particular areas of the brain that are in neural communication with the eyes. The visual
10 system is particularly well adapted for the rapid and precise extraction of spatial information from a field of view which is accomplished by analyzing the continuously changing patterns of radiant flux impinging upon the surfaces of the eyes.

15 Image formation is greatly complicated by the movement of the eyes within the head, as well as by the movement of both eyes and the head relative to the external sea of radiant energy. Visual input is ordinarily sampled by discrete momentary pauses of the
20 eyes called fixations, interrupted by very rapid ballistic motions known as saccades which bring the eye from one fixation position to the next. Smooth movements of the eyes can occur when an object having a predictable motion is available to be followed.

25 Each eye forms an image upon a vast array of light sensitive photoreceptors of the retina. The cornea is the primary refracting surface which admits light through the anterior part of the outer surface of the eye. The iris contains muscles which alter the size of the entrance port
30 of the eye, or pupil. The crystalline lens has a variable shape, under the indirect control of the ciliary muscle.

Having a refractive index higher than the surrounding media, the crystalline lens gives the eye a variable focal length, allowing accommodation to objects at varying distances from the eye.

5 Much of the remainder of the eye is filled with fluids and materials under pressure which help the eye maintain its shape. For example, the aqueous humor fills the anterior chamber between the cornea and the iris, and the vitreous humor fills the majority of the volume of the
10 eye in the vitreous chamber. The crystalline lens is contained within a third chamber of the eye, the posterior chamber, which is positioned between the anterior and vitreous chambers.

 The human eye is susceptible to a score or more of
15 disorders and diseases, a number of which attack the crystalline lens. For example, cataracts mar vision through cloudy or opaque discoloration of the lens of the eye. Cataracts often result in partial or complete blindness. If this is the case, the crystalline lens can
20 be removed and replaced with an intraocular lens, or IOL.

 While restoring vision, conventional IOLs have limited ability for accommodation (i.e., the focusing on near objects). This condition is known as presbyopia. To overcome presbyopia of an IOL, a patient may be prescribed
25 eyeglasses. Alternative attempts in the art to overcome presbyopia focus on providing IOLs with accommodation ability. Accommodation may be accomplished by either changing the shape of the IOL, e.g., to become more convex to focus on near objects, or by moving the IOL along its
30 optical axis. For example, a number of these approaches bias an IOL to be located in the most posterior position of the posterior chamber of the eye under rest conditions. When near focus is required, the ciliary muscle contracts, and the IOL moves forwardly, which is known as positive
35 accommodation. In the absence of ciliary muscle

contraction, the IOL is biased rearwardly to the most posterior position. While these approaches may provide limited accommodation, the posterior bias and the configuration of the IOL prevent sufficient forward axial movement required for full-range accommodation.

In view of the foregoing, it would be beneficial in the art to provide IOLs adapted for sufficient accommodation to reduce significantly or to overcome the effects of presbyopia.

10

Summary of the Invention

The present invention provides new and enhanced intraocular lenses (IOLs). The present IOLs enhance accommodation of an optic. More specifically, the IOLs of the present invention enhance accommodation by converting radial movement of the capsular bag to axial movement of an optic. In addition, the present IOLs may also amplify such radial movement to effect a greater degree of positive accommodation for near vision.

According to one aspect of the present invention, an intraocular lens includes an optic and a movement assembly. The optic is adapted to focus light onto a retina of an eye. The movement assembly is adapted to cooperate with the eye to effect accommodating movement of the optic along an optical axis thereof. The movement assembly includes at least one, and preferably a plurality of, movement members and a suspension structure. The movement members are coupled to a periphery of the optic. The suspension structure is coupled to the movement members and is adapted to be in contact with a peripheral region of a capsular bag of an eye. The movement members are adapted to convert radial movement of the suspension structure caused by movement of the capsular bag to axial movement of the optic.

One of the advantages of the present invention is that the movement members may be adapted to amplify the radial movement of the suspension structure. Accordingly, substantial positive accommodation for near vision is possible with a relatively small contraction of the capsular bag. For example, according to one preferred embodiment of the invention, the movement members are configured to increase or amplify radial movement of the suspension structure into axial movement of the optic by approximately 200%.

According to another aspect of the IOL of the present invention, the movement members are articulated. For example, each of the movement members may include a first segment and a second segment pivotally coupled together. A distal end of the first segment is pivotally coupled to the suspension structure, and a proximal end of the second segment is pivotally coupled to a periphery of the optic.

This articulated two-segment linkage arrangement of the movement members allows radial movement to be converted and amplified into axial movement. More specifically, radial forces directed inwardly during contraction of the capsular bag are carried by the first segment. These forces are then transferred to the second segment at a pivot disposed between the two segments. The first segment and, correspondingly, the optic are urged anteriorly. This motion is amplified as the capsular bag continues to contract as the pivot follows a curved path which is translated into substantially axial movement of the optic.

According to another aspect of the invention, the suspension structure may include a plurality of arcuate contact plates each coupled to a respective one of the movement members. The arcuate contact plates are configured to support the IOL within the capsular bag. One of the advantages of this embodiment of the present

invention is that the IOL is vigorously held within the capsular bag. More specifically, the contact plates collective have a relatively large contact surface which engages with and supports the capsular bag.

5 The relatively large surface area of the contact plates may also promote cellular and fibrous growth to this portion of the IOL, which further holds and retains the IOL within the capsular bag. Post-operative cellular and fibrous growth of the interior of the capsular bag to
10 the contact plates is facilitated by the vigorous contact of the contact surface with the capsular bag.

 In addition to promoting desired post-operative fibrous growth, the IOL of the present invention inhibits unwanted posterior capsule opacification (PCO) onto the
15 optic. To do so, the movement assembly may include a plurality of sharp discontinuities between the contact plates and the optic. Accordingly, cellular growth from the capsular bag to the optic is inhibited.

 According to another aspect of the IOL of the invention, the suspension structure may include a fulcrum
20 ring coupled to the movement members, thereby interconnecting the movement members. The first segment of each movement member rotates about the fulcrum ring during accommodation.

25 Any and all of the features described herein and combinations of such features are included within the scope of the present invention provided that the features of any such combination are not mutually inconsistent.

 Additional aspects, features, and advantages of the present
30 invention are set forth in the following description and claims, particularly when considered in conjunction with the accompanying drawings in which like parts bear like reference numbers.

Brief Description of the Drawings

Fig. 1 is a cross sectional view of an intraocular lens (IOL) according to an exemplary embodiment of the present invention implanted in a capsular bag of a human eye.

5 Fig. 2 is a plan view of an IOL configured in accordance with the present invention, particularly illustrating the IOL from a posterior side.

10 Fig. 3 is an enlarged cross sectional view of an intraocular lens (IOL) of the invention, particularly illustrating an articulated movement member of the invention.

Fig. 4A is a schematic sectional view of an IOL of the invention illustrating various positions of accommodation of an optic.

15 Fig. 4B is an on-axis elevational view of the IOL of Fig. 4A from a posterior side, particularly illustrating the IOL in a biased most-rearward position.

20 Fig. 4C is an on-axis elevational view of the IOL of Fig. 4A from an anterior side, particularly illustrating the IOL in an anterior position.

Fig. 5 is an enlarged sectional view of an IOL of the invention illustrating various positions of accommodation of an optic and corresponding movement of a movement member.

25 Fig. 6B₁ is a schematic sectional view of an IOL of the invention illustrating a most-rearward position of an optic of the IOL.

Fig. 6B₂ is an on-axis elevational view of the IOL of Fig. 6B₁, illustrating a posterior side.

30 Fig. 6B₃ is an on-axis elevational view of the IOL of Fig. 6B₁, illustrating an anterior side.

Fig. 6C₁ is a schematic sectional view of an IOL of the invention illustrating an anterior position of an optic of the IOL.

Fig. 6C₂ is an on-axis elevational view of the IOL of Fig. 6C₁, illustrating a posterior side.

Fig. 6C₃ is an on-axis elevational view of the IOL of Fig. 6C₁, illustrating an anterior side.

5 Fig. 7 is a schematic view illustrating mechanical movement of a movement member of the invention.

Description of the Preferred Embodiments

Referring to the drawings in more detail, an intraocular lens (IOL) 10 according to an exemplary embodiment of the present invention is illustrated in Figs. 1 and 2. Exemplary IOL 10 includes an optic 12 and a movement assembly 14 coupled to the optic 12. The optic 12, which has an optical axis O, is adapted to focus light onto a retina of an eye. The movement assembly 14 of exemplary IOL 10 cooperates with an eye to effect accommodating movement of the optic 12 and, in particular, converts radial movement (i.e., movement perpendicular to the optical axis O) of the capsular bag of an eye to axial movement (i.e., movement parallel to the optical axis O) of the optic 12.

Exemplary movement assembly 14 includes at least one movement members 16 and a suspension structure 18. Desirably, there are a plurality of movement members 16, each of which has a proximal region 20 and a distal region 22. (The terms "proximal" and "distal" are used herein with respect to the optical axis O.) The proximal region 20 is coupled to the optic 12 at a periphery 24 of the optic, and the distal region 22 is coupled to an inner periphery 26 of the suspension structure 18. The movement members 16 extend radially outwardly from the optic 12 to the suspension structure 18. As shown in Fig. 2, the suspension structure 18 has a contact surface 28 which is adapted to be in contact with a peripheral region 30 of a capsular bag 32 of an eye.

Briefly describing the anatomy of eye, the capsular bag 32 is connected to an annular ciliary muscle 34 by suspensory ligaments or zonules 36. The ciliary muscle 34 is the chief agent in accommodation, i.e., in adjusting the eye to focus on near objects. The zonules 36 retain the lens in position and are relaxed by the contraction of the ciliary muscle 34, thereby allowing a natural crystalline lens to become more convex.

Applying this anatomy to the present invention, exemplary IOL 10 is configured to facilitate movement of the optic 12 in response to the action of the ciliary muscle 34 and the zonules 36. When near vision is needed, the ciliary muscle 34 contracts, and the zonules 36 relax and reduce the equatorial diameter of the capsular bag 32, thereby moving the optic 12 anteriorly as indicated by arrow A in Fig. 1. This anterior movement of the optic 12 increases or amplifies the amount of positive (i.e., near) accommodation of the optic 12. Conversely, when the ciliary muscle 34 relaxes, the zonules 36 constrict and increase the equatorial diameter of the capsular bag 28, thereby moving the optic posteriorly as indicated by arrow P in Fig. 1. The accommodating movement principles of the present invention are discussed in detail below.

With particular reference to Fig. 2, exemplary suspension structure 18 may include a plurality of arcuate contact plates 38 respectively coupled to the movement members 16. As shown in FIG. 1, each of the contact plates 38 is configured to complement the inner peripheral region 30 of the capsular bag 32. Exemplary movement assembly 14 may include a fulcrum ring 40 coupled between each of the movement members 16, preferably at the distal regions 22 thereof, to interconnect the movement members. Defined between each of the contact plates 38 is a gap or a joint 42 for allowing the plates to move independently of each other in response to contraction and expansion of

the capsular bag 32. Therefore, in accordance with the exemplary embodiment shown in the drawings, the suspension structure 18 is configured as a plurality of suspended pivotal arcuate contact plates 38 that are capable of moving responsively with the capsular bag 32.

In conjunction with the contact plates 38 of the suspension structure 18, exemplary movement members 16 of the movement assembly 14 are configured to articulate in response to contraction and expansion of the capsular bag 32. Preferably, exemplary movement members 16 are configured to convert radial movement of the arcuate plates 38 into axial movement of the optic 12. Yet more preferably, exemplary movement members 16 are configured to amplify such radial movement to provide axial movement with a magnitude greater than the radial movement. It should be noted that although a plurality of movement members 16 are shown, a single movement member having the described radial-to-axial movement amplification property is within the scope of the present invention. For example, the movement members 16 may be integrally formed (i.e., molded) as a single annular element, and thus be considered to be one piece. Alternatively, a conical coil spring or other such single member may be used with appropriate coupling structure.

More specifically, with continued reference to Figs. 1 and 2 and with additional reference to Fig. 3, each of the movement members 16 includes a first segment 44 and a second segment 46 coupled together at a pivot 48. The distal region 22 of the first segment 44 of each movement member 16 is pivotally coupled to a respective one of the arcuate contact plates 38 at a distal pivot point 50. The proximal region 20 of the second segment 46 of each movement member 16 is flexibly or pivotally coupled to the periphery 24 of the optic 12 at a proximal pivot point 52. Accordingly, each of the movement members 16 is configured

as an articulated multi-segment linkage which, as will be discussed clearly below, translates and amplifies radial movement of the contact plates 38 into axial movement of the optic 12. It should be noted that, in this respect,
5 "articulated" has the traditional meaning of elements united by a joint or joints.

This translation and amplification feature of the IOL 10 of the present invention is illustrated in Figs. 4, 5, and 6. Exemplary IOL 10 is shown in Fig. 4A in various states of accommodation. For example, a biased most-posterior position of the optic 10 is indicated by arrow B, shown on-axis from a posterior side in Fig. 4B, in which position the ciliary muscle 34 is relaxed in response to a need for far vision. In addition, an
10 anterior position of the optic 12 is indicated by arrow C in Fig. 4A, shown on-axis from a posterior side in Fig. 3C, in which position the ciliary muscle 34 is contracted in response to a need for near vision. An intermediate
15 position of the optic 12 is also shown in Fig. 4A, indicated by arrow I.
20

Figs. 6B₁ to 6B₃ illustrate the posterior position B, namely, with respect to a fixed plane F in Fig. 6B₁, on-axis from a posterior side in Fig. 6B₂, and on-axis from an anterior side in Fig. 6B₃. Figs. 6C₁ to 6C₃ illustrate the anterior position C, namely, with respect to the fixed
25 plane F in Fig. 6C₁, on-axis from a posterior side in Fig. 6C₂, and on-axis from an anterior side in Fig. 6C₃.

In operation during positive accommodation, if the IOL 10 is in the biased most-rearward position B and near
30 vision is needed, the ciliary muscle 34 contracts as indicated by arrow N in Fig. 4A. In response, the contact plates 38 move inwardly toward the optical axis O from an expanded equatorial diameter D_e. In doing so, with specific reference to Fig. 5, a force F₁ along the first
35 segment 44 of the movement member 16 is translated into a

force F_2 along the second segment 46 of the movement member at the pivot 48, thereby urging the optic 12 anteriorly to an intermediate position I and causing the first segment 44 to pivot anteriorly at the distal pivot point 50 through an angle α_1 . Alternatively, the IOL 10 may be oppositely configured and biased into the most-forward position (not shown) providing near vision, wherein far vision is obtained by rearward motion of the optic 12.

This translation in force amplifies the magnitude of the radial distance that the optic 12 moves. For example, and again with reference to Fig. 5, if the contact plates 38 move radially inwardly a distance r_1 between posterior position B and intermediate position I, then the optic 12 moves axially anteriorly a distance a_1 between these two positions. Accordingly to the present invention, the magnitude of axial distance a_1 is greater than that of radial distance r_1 . The second segment 46 of exemplary movement member 16 may include a concave surface 54 configured to accommodate the periphery 24 of the optic 12 when in an intermediate position I during accommodation.

As the ciliary muscle 34 continues to contract, the force F_1 along the first segment 44 continues to be translated into the force F_2 along the second segment 46, thereby urging the optic 12 anteriorly from intermediate position I to anterior position C and causing the first segment 44 to pivot anteriorly at the distal pivot point 50 through an angle α_2 . If the contact plates 38 move radially inwardly a distance r_2 between intermediate position I and anterior position C, then the optic 12 moves axially anteriorly a distance a_2 , the magnitude of which is greater than the magnitude of radial distance r_2 .

Accordingly, the magnitude of a total axial distance a_T

the optic 12 moves during accommodation (either positive or negative) is greater than a total radial distance r_T that the distal pivot point 50 moves, or:

$$|a_T| > |r_T|$$

5 For example, the IOL 10 of the present invention may be configured so that a radial movement of the distal pivot point 50 in a magnitude of about 0.5 mm results in an axial movement of the optic 12 in a magnitude of about 2.0 mm. More generally, according to a preferred embodiment
10 of the invention, the IOL 10 is configured so that the movement members 16 amplify radial distances r into axial distances a by at least about 100%, and preferably by about 200%.

With continued reference to Fig. 5 and additional
15 reference to Fig. 7, the amplification in distance results in part from a relatively long first link or segment 44 of the movement member 16 indicated by l_1 and a relatively short second link or segment 46 of the movement member 16 indicated by l_2 . The movement members 16 are configured
20 such that the first and second segments 44 and 46 are angulated and converge posteriorly toward the pivot 48 when the IOL 10 is in the most-rearward position B; that is, the pivot 48 is the most posterior element of the movement member 16 when in posterior position B.

25 With particular reference to Fig. 7, during accommodation, the pivot 48 (i.e., a proximal end of the first segment 44 and the distal end of the second segment 46) follows a curved path Λ indicated by the dashed line. In other words, the pivot 48 moves arcuately during
30 accommodation. When the IOL 10 is in the anterior position C, the first segment 44 is angulated anteriorly, while the second segment 46 remains in a posterior angulated orientation. Accordingly, the pivot 48 has a

pivotal range that preferably does not exceed 180 degrees. In addition, it is preferable for the pivot 48 to be biased to return to its most-posterior orientation of position B.

5 The path Λ shown in Fig. 7 has an angular distance that is approximately equal to the product of the first length l_1 and the total change in angular position of the first segment 44 with respect to a radial axis R. It should be noted, however, that the path Λ is not a segment
10 of a circumference of a perfect circle because the vertex of the angle α moves radially; accordingly, each change in arc length $\Delta\lambda$ does not equal the exact product of the corresponding change in angle and length l_1 .

15 With continued reference to Figs. 5 and 7, the angular motion of the pivot 48 is translated to linear (i.e., axial) motion by the two-arm articulated movement member 16. More specifically, as the distal pivot point 50 (i.e., the distal end of the first segment 44) moves radially along radial axis R, the proximal pivot point 52
20 (i.e., the proximal end of the second segment 46) moves axially along an axial axis A. In other words, the distal end 22 of the movement member 16 (i.e., distal pivot point 50) is restricted to only radial movement (and no axial movement) along the radial axis R, and the proximal end 20
25 (i.e., proximal pivot point 52) is restricted to only axial movement (and no radial movement) along axial axis A. Rigid contact and engagement between the contact plates 38 and the capsular bag 32 prevents axial movement of the distal pivot point 50, and the optic 12 with a
30 constant equatorial diameter prevents radial movement of the pivot point 52.

To accomplish negative accommodation, a restoring force F_R , as indicated in Fig. 5, is provided by the

elastic tension of the zonules 36. The contact surfaces 28 of the contact plates 38 provide a collective large surface area subject to cellular and fibrous growth to the capsular bag 32 so that when the ciliary muscle 34
5 relaxes, the zonule tension draws the capsular bag and the contact plates 38 (and, accordingly, the distal pivot point 50) outwardly.

Post-operative cellular and fibrous growth of the interior of the capsular bag 32 to the contact surfaces 28
10 of the contact plates 38 improves functioning of the IOL 10. To further facilitate this controlled fibrosis, the contact surfaces 28 may include depressions or holes (not shown) which provide a purchase on which cells and fibrin may grow. It is anticipated that this cellular and
15 fibrous growth may take place within the first few weeks after the IOL 10 is implanted in an eye. Accordingly, the IOL 10 is permanently attachable to the capsular bag 32. This vigorous attachment of the IOL 10 to the capsular bag 32 ensures that the optic 12 moves axially in direct
20 response to changes in the capsular bag 32. The coupling of the contact plates 38 with the capsular bag 32 may also be accomplished with a biological glue.

Additional restoring force for facilitating negative accommodation may be provided by rearward biasing of the haptic 16. For example, a spring force may be induced and
25 stored by the pivot 48 during positive accommodation; accordingly, when the ciliary muscle 34 relaxes, the spring force may urge the two segments 44 and 46 together. In this regard, the pivot 48 may be configured as a living
30 hinge which is biased to return to the configuration when the IOL 10 is the posterior position B. Similarly, the connection of the first segments 44 of the haptics 16 and the contact plates at the distal pivot points 50 may be configured so that a spring force is induced and stored
35 during positive accommodation, which force is released

when the ciliary muscle 34 relaxes. Those skilled in the art will appreciate that the mechanical operation of exemplary IOL 10 during negative accommodation when the ciliary muscle 34 relaxes is analogous to the foregoing description in reverse order.

Although controlled fibrosis (i.e., cellular growth) on the contact surfaces 28 of the contact plates 38 is promoted, the IOLs 10 of the invention inhibit cell growth, particularly epithelial cell growth, onto the optic 12. This is accomplished by configuring the contact plates 38 with mechanical barriers such as sharp posterior and anterior edges 56 shown in Fig. 1. The proliferation of unwanted epithelial cell growth may also be inhibited through the use of material properties.

For human implantation, exemplary IOL 10 may be configured such that the amount of positive or near accommodation is preferably at least about 1 diopter and may range up to 3.5 diopters or more. Further, exemplary IOL 10 may be configured to provide at least about 2.0 mm of axial movement anteriorly in the eye with about a reduction of about 2.0 mm in the equatorial diameter of the capsular bag 32 caused by the ciliary muscle 34 and the zonules 36.

The optic 12 may be constructed of rigid biocompatible materials such as polymethyl methacrylate (PMMA) or deformable materials such as silicone polymeric materials, acrylic polymeric materials, hydrogel polymeric materials, and the like. The deformable materials allow the IOL 10 to be rolled or folded for insertion through a small incision into the eye. Although the optic 12 as shown is a refractive lens body, the present IOLs may include a diffractive lens body, and such embodiment is included within the scope of the present invention.

The optic 12 may be either integral with or mechanically coupled to the movement assembly 14. The

assembly 16 may be constructed of the same or different biocompatible materials as the optic 12, and is preferably made of polymeric materials such as polypropylene, silicone polymeric materials, acrylic polymeric materials, and the like. The movement assembly 14 is preferably deformable in much the same manner as the optic 12 to facilitate the passage of the IOL 10 through a small incision into the eye. The material or materials of construction from which the movement assembly 14 is made are chose to provide the assembly with the desired mechanical properties, e.g., strength and deformability, to meet the needs of the particular application involved.

The IOL 10 may be inserted into the capsular bag 32 of a mammalian eye using conventional equipment and techniques, for example, after the natural crystalline lens is removed using a phacoemulsification technique. The IOL 10 is preferably rolled or folded prior to insertion into the eye to be insertable through a small incision, for example, on the order of about 3.2 mm. After insertion, the IOL 10 may be positioned in the eye as shown in Fig. 1.

If the IOL 10 is to be implanted in an adult human eye, the optic 12 preferably has a diameter in the range of about 3.5 mm to about 7 mm and, more preferably, in the range of about 5 mm to about 6 mm. Further, the IOL 10 may have an overall diameter, with the movement assembly 14 in an unstressed condition, of about 8 mm to about 11 mm or 12 mm. Additionally, the optic 12 preferably has a far-vision correction power for infinity in an unaccommodated state.

The present invention provides accommodating IOLs and methods for using such IOLs. The IOLs of the invention are configured to reduce the stretching of the capsular bag, to maintain the elasticity and/or integrity of the capsular bag, to enhance the effectiveness of the eye,

particularly the function of the ciliary muscle and the zonules. The present IOLs promote the secure retention within the capsular bag by providing an enlarged contact surface to which cells and fibrin may grow. In addition,
5 the present IOLs inhibit posterior capsule opacification (PCO).

While the present invention has been described with respect to various specific examples and embodiments, it is to be understood that the invention is not limited
10 thereto and that it can be variously practiced within the scope of the following claims.

WHAT IS CLAIMED IS:

1. An intraocular lens comprising:
an optic adapted to focus light onto a retina of an
eye and having an optical axis; and
a movement assembly adapted to cooperate with the eye
5 to effect accommodating movement of the optic and
including:

At least one movement member coupled to the
optic; and
a suspension structure coupled to the movement
10 member and adapted to be in contact with a peripheral
region of a capsular bag of an eye;
the movement member being adapted to convert and
amplify radial movement of the suspension structure caused
by movement of the capsular bag to axial movement of the
15 optic.

2. The intraocular lens of claim 1 wherein the
movement member is articulated.

3. The intraocular lens of claim 1 wherein there
are a plurality of movement members each of which includes
a first segment and a second segment;
the first segment having a distal end pivotally
5 coupled to the suspension structure and a proximal end;
the second segment having a distal end pivotally
coupled to the proximal end of the first segment and a
proximal end pivotally coupled to a periphery of the
optic.

4. The intraocular lens of claim 3 wherein the
suspension structure includes a plurality of arcuate
contact plates each coupled to a first segment of a
respective one of the movement members.

5. The intraocular lens of claim 4 wherein the suspension structure includes a fulcrum ring pivotally coupled between the contact plates and the movement members.

6. The intraocular lens of claim 5 wherein the fulcrum ring moves axially during accommodation.

7. The intraocular lens of claim 3 wherein the first segment and the second segment are coupled at a pivot;

5 the pivot following a curved path during accommodation.

8. The intraocular lens of claim 3 wherein the second segment is coupled to the optic at a pivot point; the pivot point moving axially during accommodation.

9. The intraocular lens of claim 3 wherein the movement members are biased to be in a most-rearward position.

10. The intraocular lens of claim 3 wherein the movement members are biased to be in a most-forward position.

11. The intraocular lens of claim 3 wherein the first segment is longer than the second segment.

5 12. The intraocular lens of claim 3 wherein the movement members are configured so that substantially radial forces along the first segment caused by a contraction of the ciliary muscle on the capsular bag are translated into substantially axially forces along the second segment.

13. The intraocular lens of claim 1 wherein the movement member is adapted to amplify radial movement of the suspension structure into axial movement of the optic by at least approximately 100%.

14. An intraocular lens comprising:

an optic adapted to focus light onto a retina of an eye and having an optical axis; and

5 a movement assembly adapted to cooperate with the eye to effect accommodating movement of the optic and including:

a plurality of articulated movement members coupled to the optic; and

10 a suspension structure including a plurality of arcuate contact plates coupled to the movement members and adapted to be in contact with a peripheral region of a capsular bag of an eye;

the movement members being adapted to convert radial movement of the contact plates caused by movement of the capsular bag to axial movement of the optic.

15. The intraocular lens of claim 14 wherein:

each of the movement members includes a first segment and a second segment coupled together at a pivot; and

5 the suspension structure includes a fulcrum ring coupled to an inner periphery of each of the contact plates;

a distal end of the first segment of each of the movement members being coupled to the fulcrum ring; and

10 a proximal end of the second segment of each of the movement members being coupled to a periphery of the optic at a pivot point.

16. The intraocular lens of claim 15 wherein the first segment of each of the movement members is angulated posteriorly when the optic is in a most-rearward position.

17. The intraocular lens of claim 16 wherein the first segment of each of the movement members is angulated anteriorly when the optic is in an anterior position resulting from positive accommodation.

18. The intraocular lens of claim 17 wherein the pivots move arcuately and the pivot points move axially during accommodation.

19. The intraocular lens of claim 14 wherein the movement members are further adapted to amplify the radial movement of the suspension structure.

20. A method for accommodating near vision in an intraocular lens, the method comprising the steps of:

providing an intraocular lens including:

an optic adapted to focus light onto a retina of an eye; and

a movement assembly including:

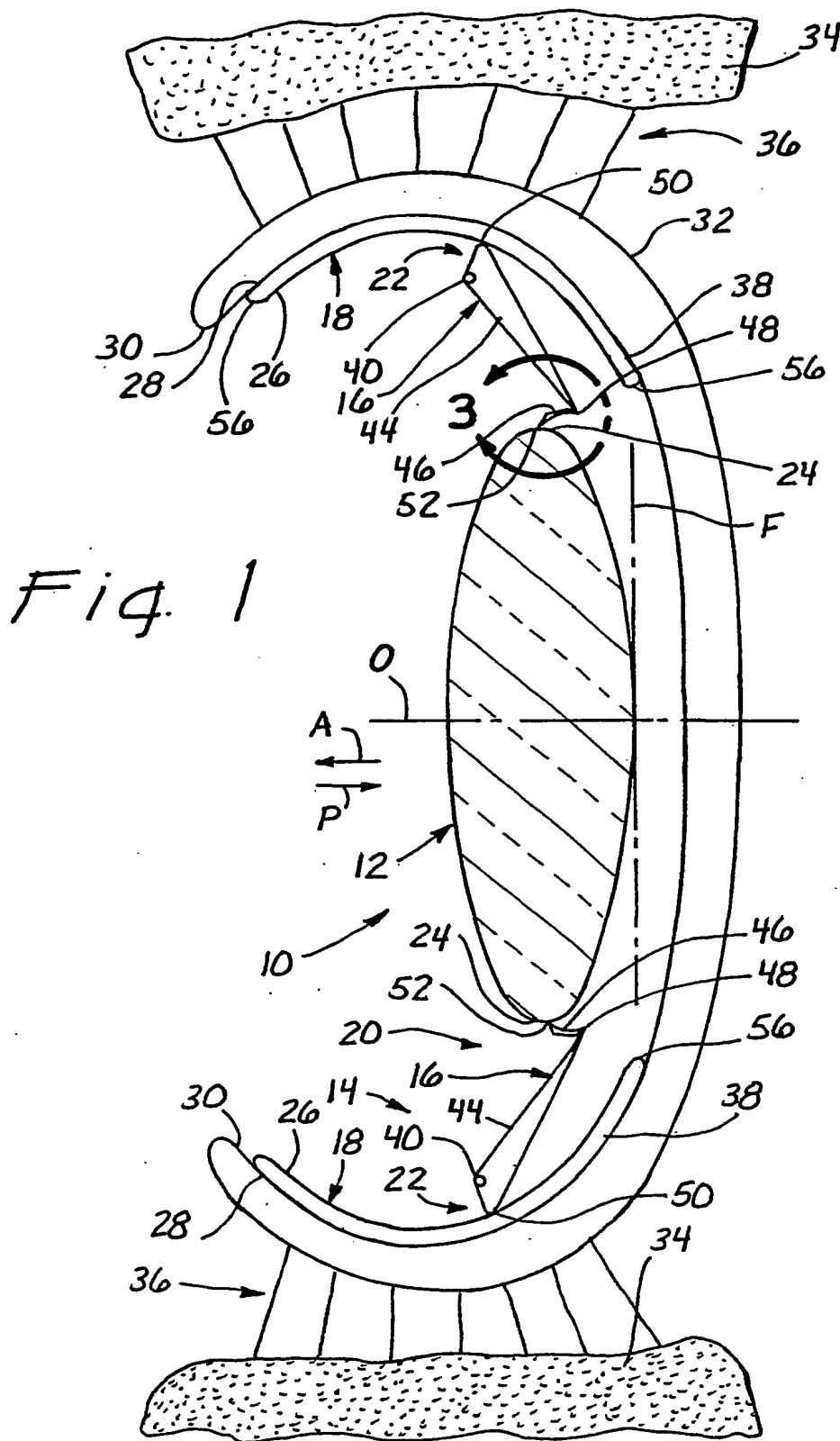
a plurality of movement members coupled to the optic; and

a suspension structure coupled to the movement members and adapted to be in contact with a peripheral region of a capsular bag of an eye; and

amplifying radial movement of the suspension structure caused by movement of the capsular bag to a greater axial movement of the optic.

21. The method of claim 20 wherein the amplifying step comprises the step of:

amplifying the radial movement of the suspension structure by
at least about 100%.



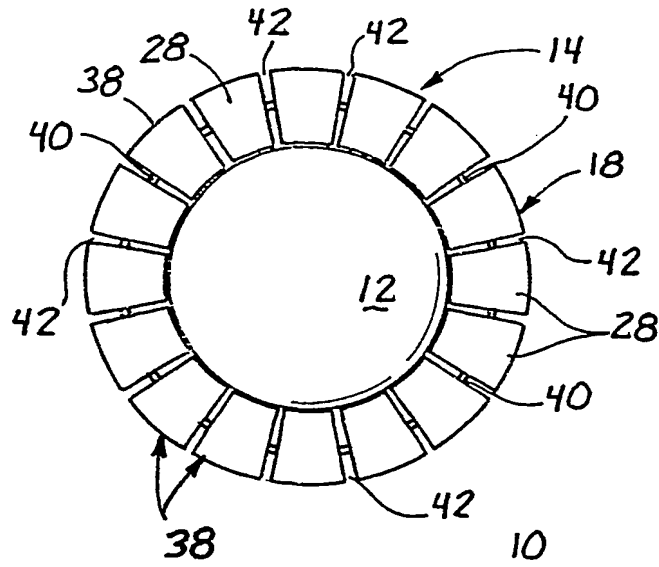


Fig. 2

Fig. 3

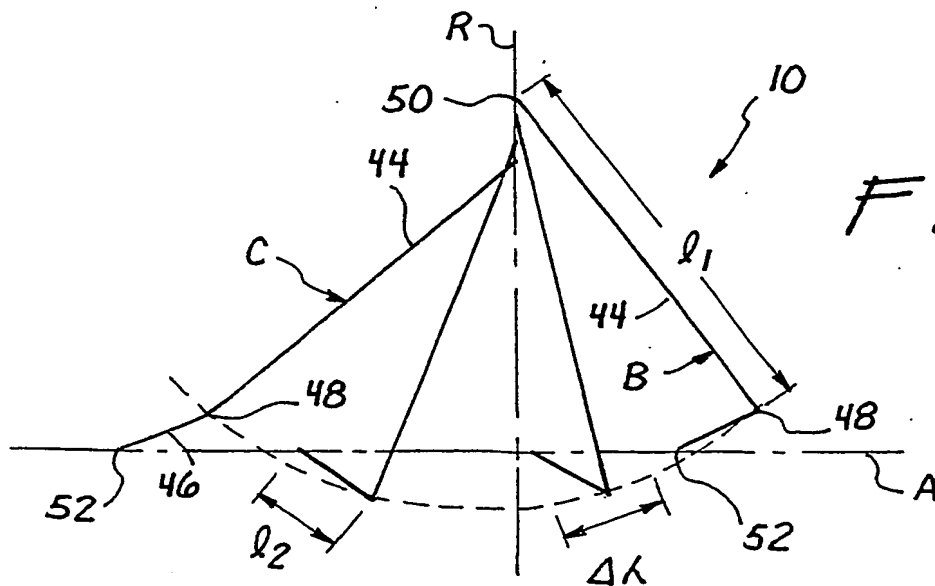
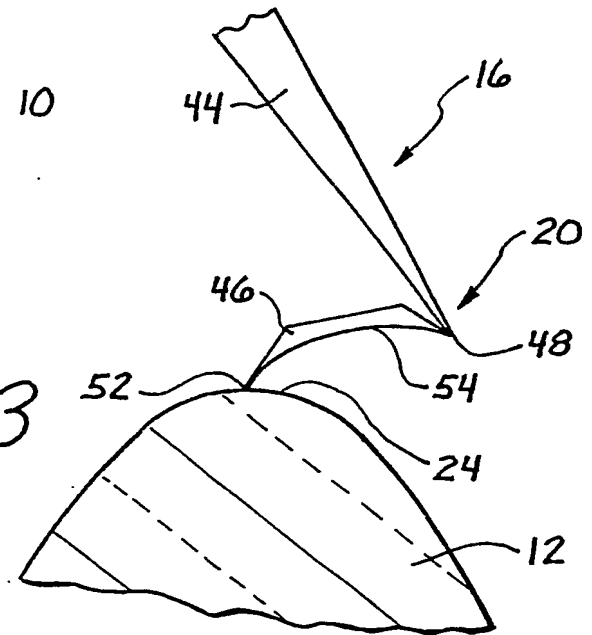


Fig. 7

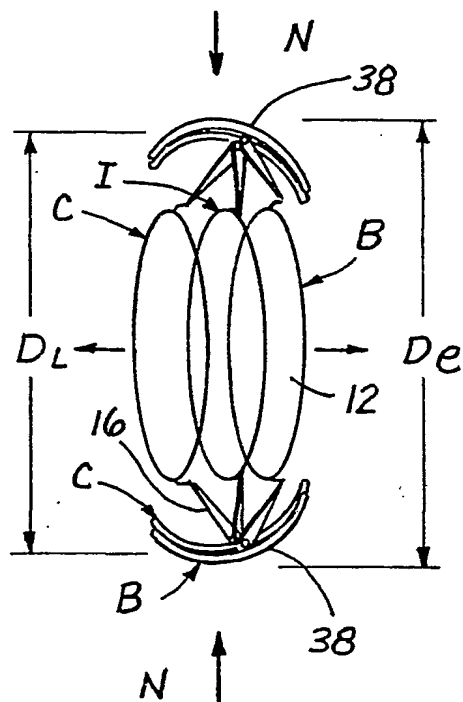


Fig. 4A

Fig. 4B

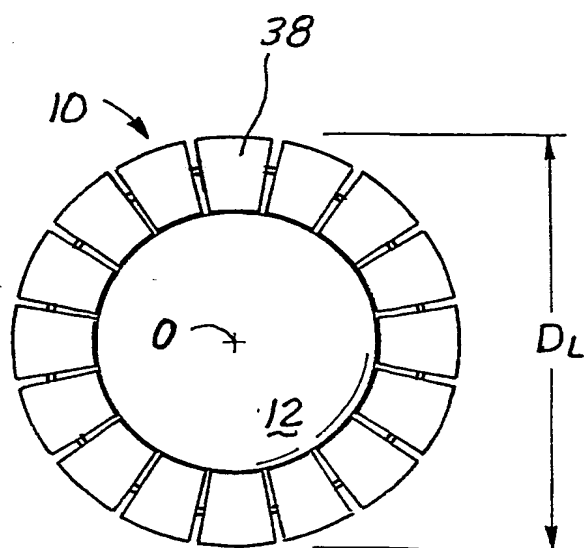
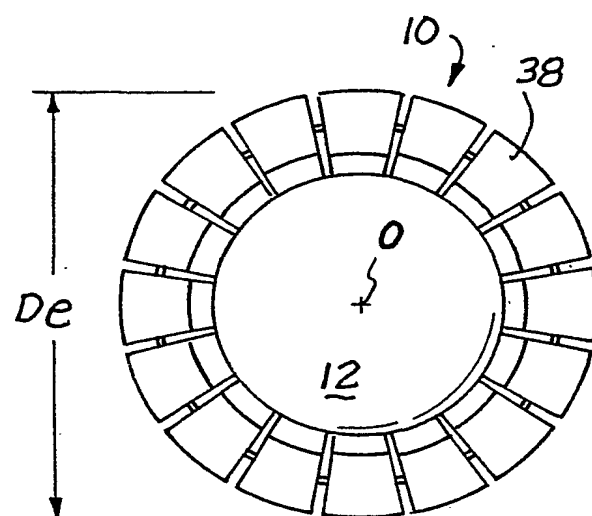
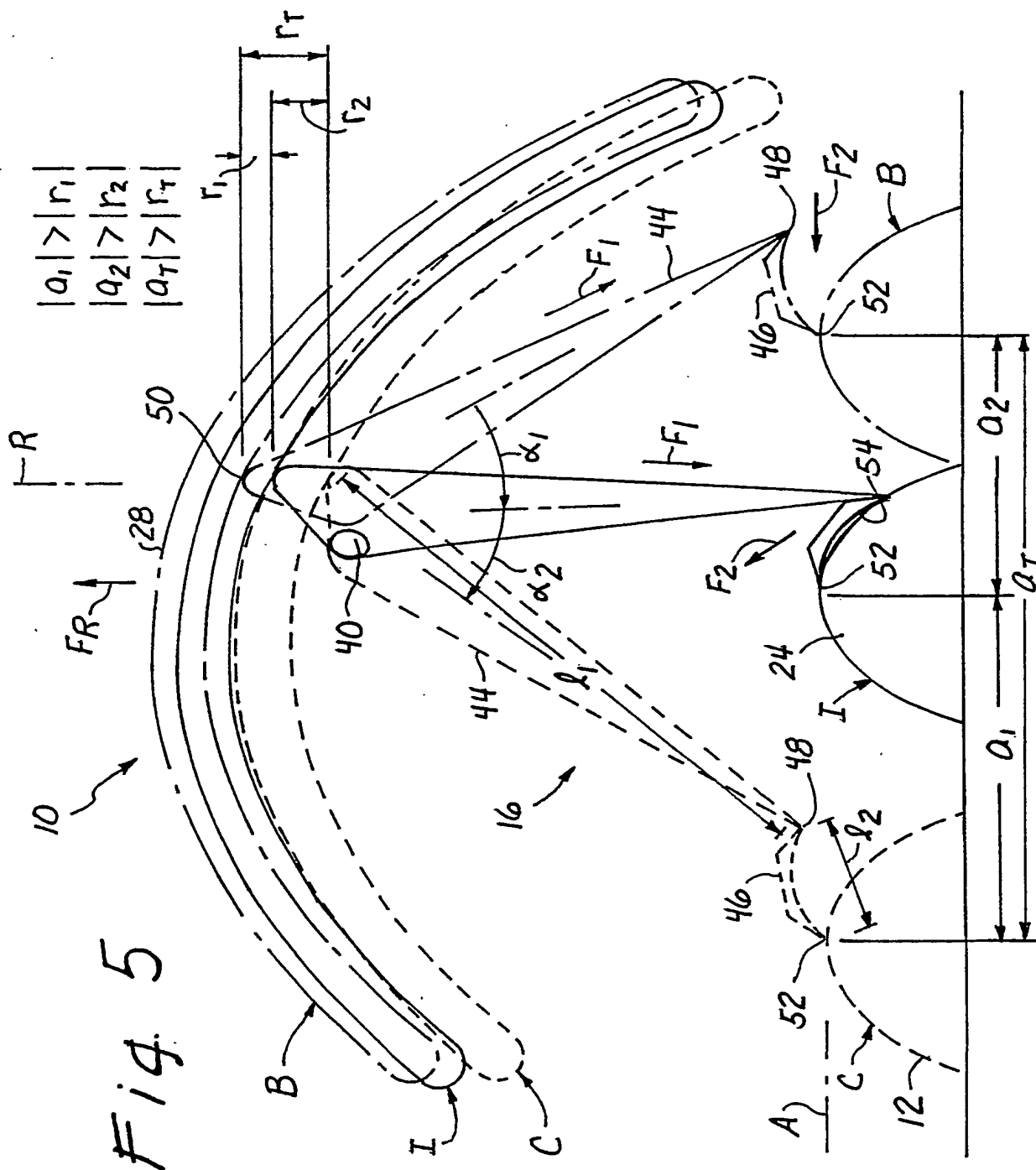
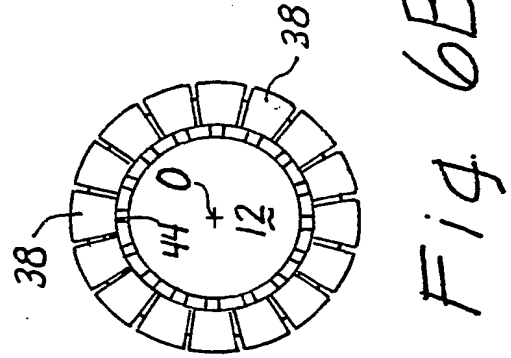
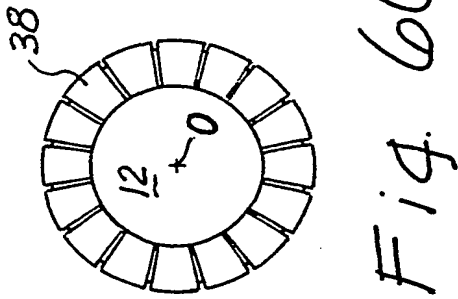
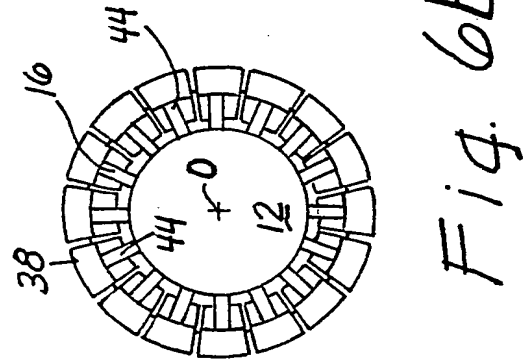
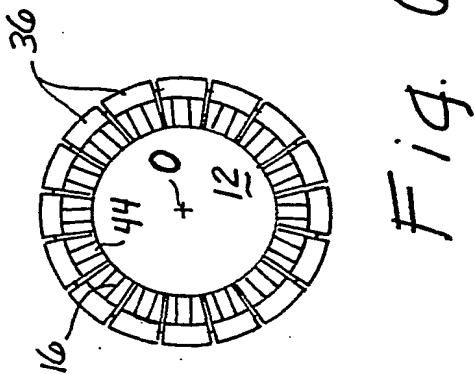
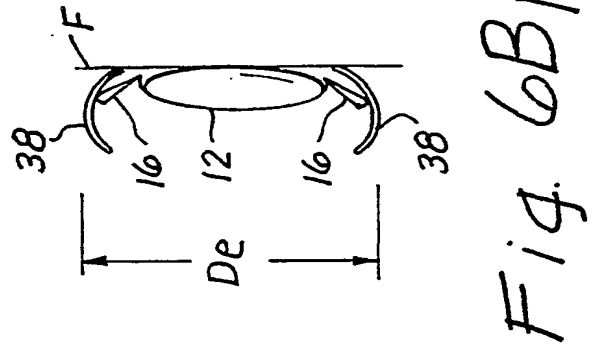
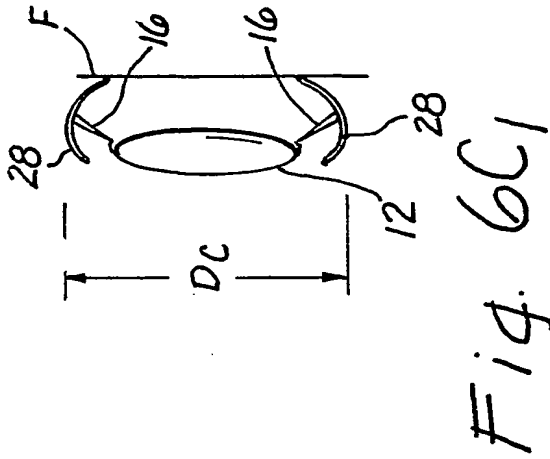


Fig. 4C





INTERNATIONAL SEARCH REPORT

Int al Application No

PCT/US 01/23508

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 A61F2/16

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 A61F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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X	WO 96 25126 A (CUMMING J STUART) 22 August 1996 (1996-08-22) page 19, line 1 - page 22, line 5; figures page 25, line 1 - line 23	1-4, 7-9, 11-14, 19
X	WO 96 15734 A (ACUITY ISRAEL LIMITED ; ISRAEL HENRY M (IL)) 30 May 1996 (1996-05-30) page 15, line 13 - line 31; figures 10-12 page 21, line 7 - line 35 page 28, line 3 - page 29, line 18	1, 2, 4, 13, 14
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X	EP 0 337 390 A (CESKOSLOVENSKA AKADEMIE VED) 18 October 1989 (1989-10-18) abstract	1, 14
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☒ Further documents are listed in the continuation of box C.☒ Patent family members are listed in annex.

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Date of the actual completion of the international search

9 January 2002

Date of mailing of the international search report

15/01/2002

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INTERNATIONAL SEARCH REPORT

In ~~US~~ Application No
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